



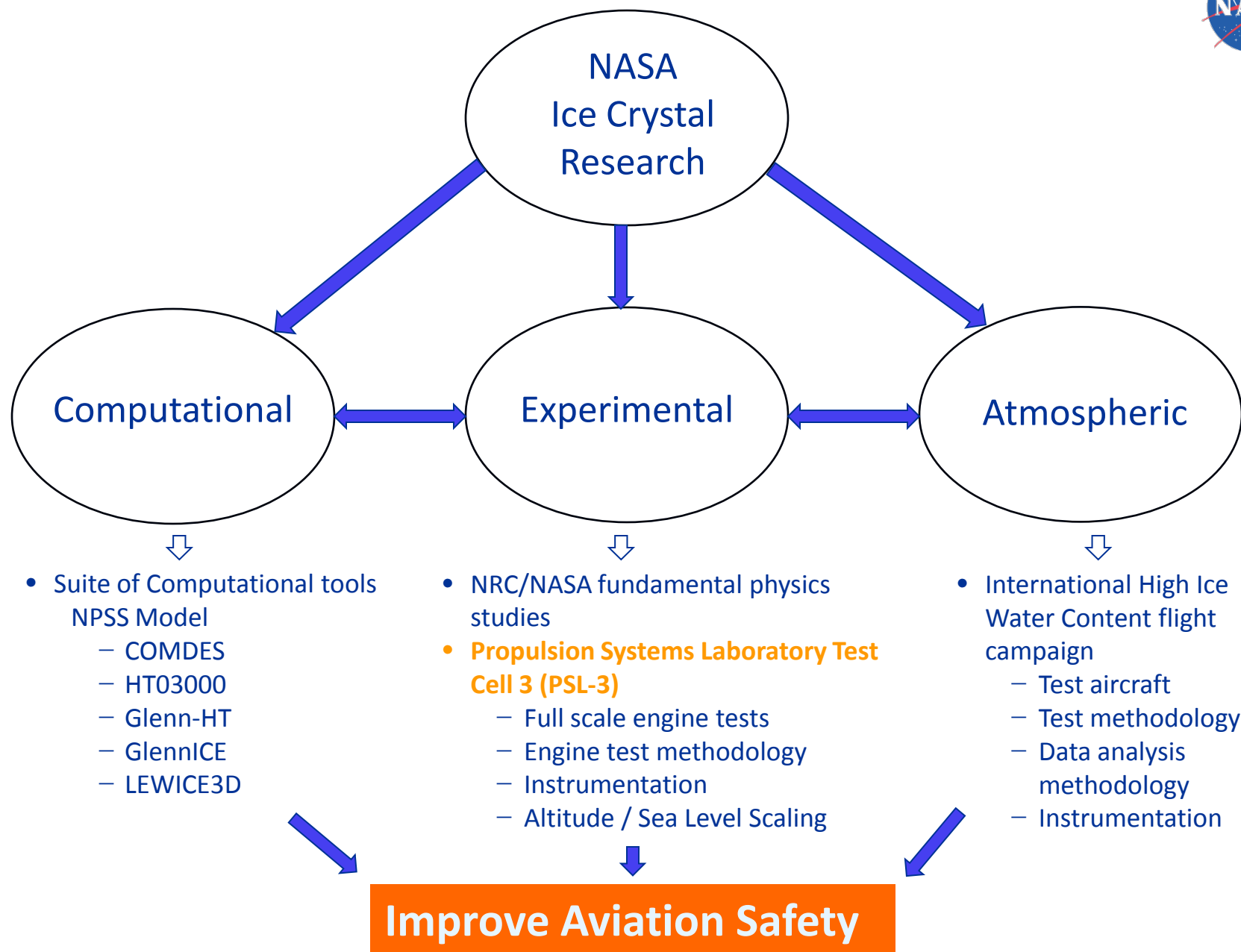
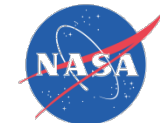
## NASA GRC PSL-3 Technical Challenges

**Full Scale Engine Test Facility  
Altitude and Sea Level Testing  
in an Ice Crystal Environment**



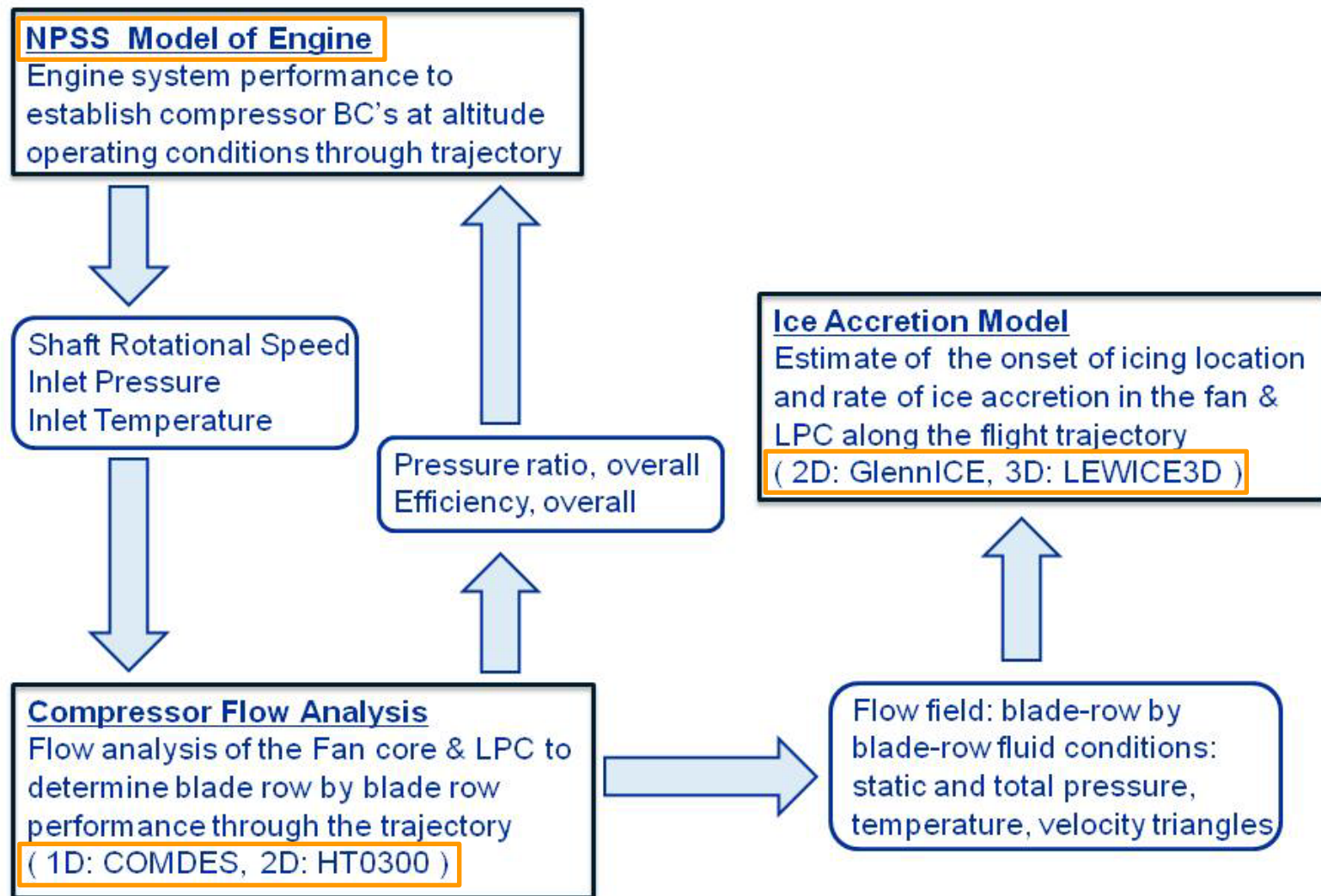
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# Computational Research Diagram



# Flight Campaign to Characterize HIWC Environment

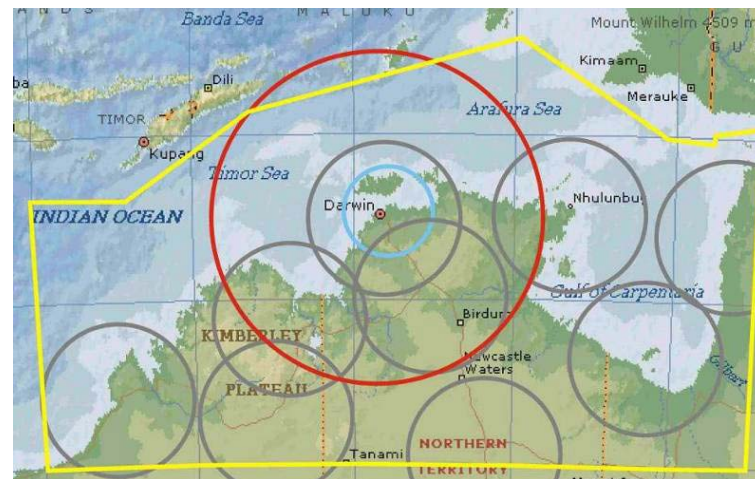
**Objective:** Obtain quantitative natural cloud information needed for research

**Approach:** Conduct flight campaigns in natural conditions

- Trial campaign to check instruments and methods (2012)
- Primary campaign to collect data (Jan 2013)

## International Collaborative Effort:

NASA, FAA, Environment Canada, NRC-Canada, Transport Canada, Australian BOM, Boeing, NCAR, SEA, FTA, Airbus





## Propulsion Systems Laboratory Test Cell 3 (PSL-3)

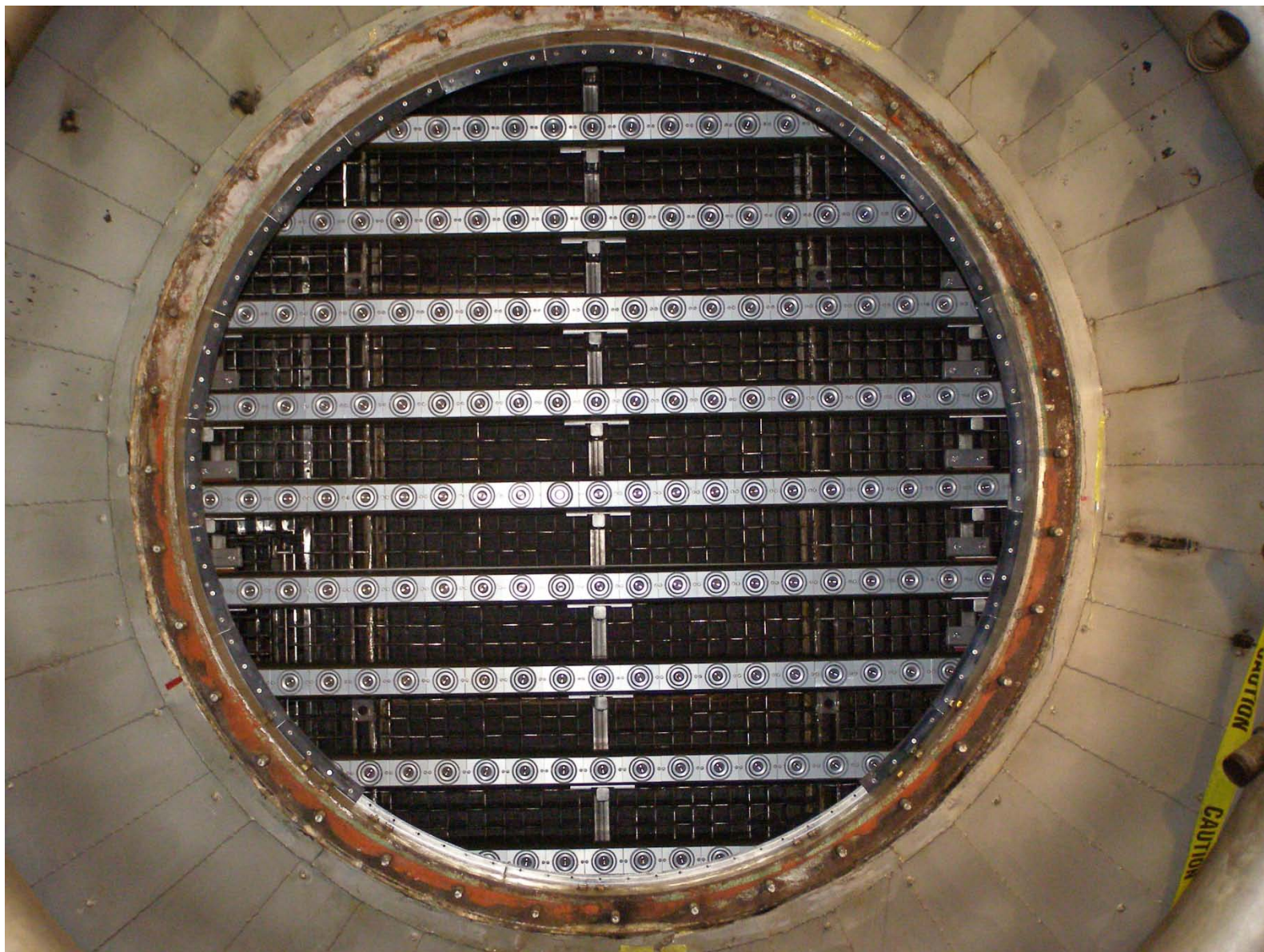


## PSL-3 Spraybars





# PSL-3 Spraybars ALF View



# Spraybar Details

## Glycol System

- 50 Ton Chiller
- Feeds Cooling Air, Atomizing Air and Spray Water heat exchangers
- Condenser uses cooling tower water

## Spray Water System

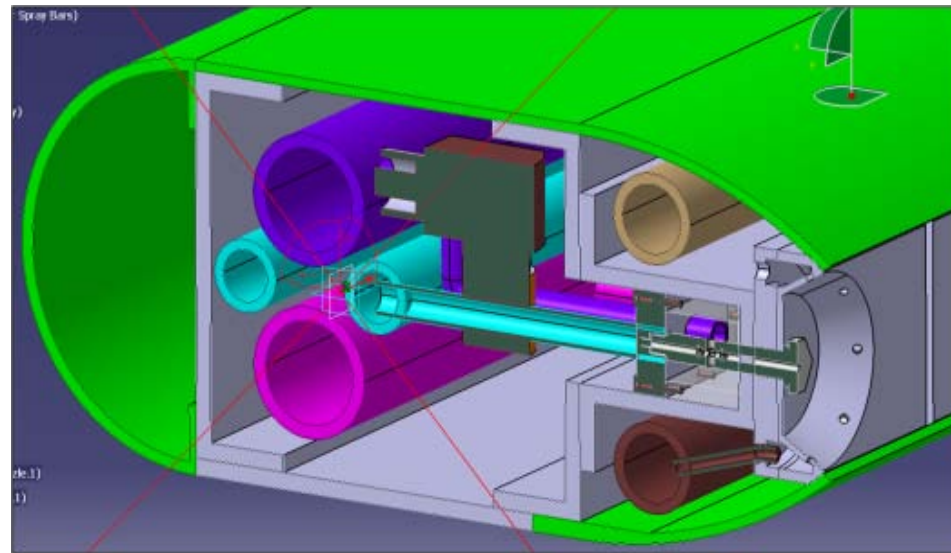
- Filtered city water
- Has re-circulating loop that includes holding tank, glycol heat exchanger, particle injection system, and boost pumps

## Atomizing Air

- Supplied from 6" Shop Air header (100 psi)
- Glycol heat exchanger reduces temperature
- Control valves set required pressure

## LN2 System

- 3,000 gal. Dewar, vacuum jacketed pipe, heat exchanger, flash tank and vent stack
- delivered to heat exchanger
- control valve used to modulate flow for desired set point on cooling air



## Cooling Air

- Supplied from 6" Shop Air header (100 psi)
- Desiccant dried
- Cooled by glycol and LN2 heat exchangers
- Control valves set required pressure for spray bars





## PSL-3 Capabilities

Propulsion System Laboratory	
Pressure Altitude (ft)	1,000 to 90,000
Min. Static Temperature (F)	-50
Max. Mass flow (lbm/sec)	330
Thrust Stand Capacities (lbf)	10k, 40k and 50k
Test Cell ( $\phi$ ft x L ft)	24 x 39

## Technical Challenges

Calibration

Control

Reliability

Instrumentation

Test Methodology

Altitude Scaling

## PSL-3 Targeted Ice Crystal Capabilities

Propulsion System Laboratory Ice Crystal Capabilities	
Pressure Altitude (ft)	4,000 to 40,000
Min. Static Temperature (F)	-50
Max. Mass flow (lbm/sec)	330
Thrust Stand Capacities (lbf)	10k, 40k and 50k
Direct Connect Test Cell ( $\phi$ ft)	3 ft
Ice Particle Size, MVD (microns)	40-60
Ice Water Content, IWC, (g/m <sup>3</sup> )	0.5 to 9



## PSL-3 Deliverables

1. Validated high altitude, ice crystal, full scale engine test facility
2. Research data to support NASA mission: *Improve Aviation Safety*
3. Altitude /ice crystal facility engine test techniques, practices and standards
4. Novel facility and engine instrumentation
5. Altitude Scaling Laws

PSL-3 Artist Rendering  
-GVIS LAB NASA GRC et.al



## Questions?

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